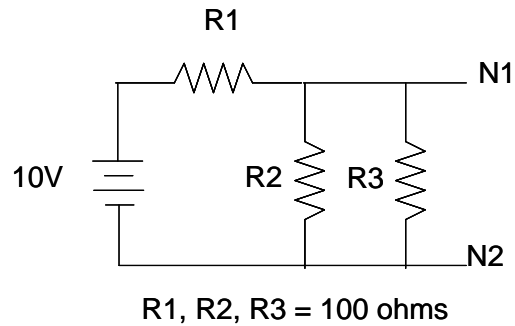




## Using CHatGPT-4 to Design Hardware Circuits

To determine if ChatGPT-4 is capable of solving hardware design problems we tested it with some design problems. This question is part of our interview process for hardware engineers. The question is to find the Thevenin and Norton equivalent for this circuit.



### INPUT

The following prompt was provided.

*For this question the accuracy of the answer is important and will require mathematical calculations. Please double check the results of all calculations.*

*An electrical circuit consisting of a 10V battery and three resistors R1, R2 and R3.*

*R1 = 100 ohms.*

*R2 = 100 ohms.*

*R3 = 100 ohms.*

### CIRCUIT WIRING

*The following describes how the battery and resistors are wired.*

*The negative side of the 10V battery is connected to pin 2 of R2 and R3*

*The positive side of the 10V battery is connected to Pin 1 of R1*

*Pin 2 of R1 is connected to R2 pin 1 and R3 pin 1*

*N1 is connected to Pin 1 of R3*

*N2 is connected to Pin 2 of R3*

*What is the Thevenin equivalent of this circuit from the perspective of N1 and N2?*



## ChatGPT-4 RESULT

To find the Thevenin equivalent of the circuit, we need to determine the Thevenin voltage ( $V_{th}$ ) and the Thevenin resistance ( $R_{th}$ ) as seen from the perspective of terminals N1 and N2.

First, let's analyze the circuit:

1.  $R_1$  is in series with the parallel combination of  $R_2$  and  $R_3$ .
2. The parallel combination of  $R_2$  and  $R_3$  is connected to the 10V battery.

Now let's find the equivalent resistance ( $R_{eq}$ ) of the parallel combination of  $R_2$  and  $R_3$ :

$$\frac{1}{R_{eq}} = \frac{1}{R_2} + \frac{1}{R_3} \quad \frac{1}{R_{eq}} = \frac{1}{100} + \frac{1}{100} \quad \frac{1}{R_{eq}} = \frac{2}{100} \quad R_{eq} = \frac{100}{2} = 50 \text{ ohms}$$

Now, the total resistance in the circuit is the sum of  $R_1$  and the equivalent resistance of the parallel combination of  $R_2$  and  $R_3$ :

$$\begin{aligned} R_{total} &= R_1 + R_{eq} \\ R_{total} &= 100 + 50 \\ R_{total} &= 150 \text{ ohms} \end{aligned}$$

Now we can find the total current ( $I_{total}$ ) in the circuit:

$$\begin{aligned} I_{total} &= \frac{V_{battery}}{R_{total}} \\ I_{total} &= \frac{10V}{150 \text{ ohms}} \\ I_{total} &= \frac{1}{15} \text{ A} \end{aligned}$$

Now we can find the voltage drop across the parallel combination of  $R_2$  and  $R_3$  ( $V_{R_2R_3}$ ):

$$V_{R_2R_3} = I_{total} * R_{eq} \quad V_{R_2R_3} = \left(\frac{1}{15} \text{ A}\right) * 50 \text{ ohms} \quad V_{R_2R_3} = \frac{50}{15} \text{ V}$$

The Thevenin voltage ( $V_{th}$ ) is equal to the voltage drop across the parallel combination of  $R_2$  and  $R_3$ :

$$V_{th} = V_{R_2R_3} = \frac{50}{15} \text{ V}$$



Next, we need to find the Thevenin resistance ( $R_{th}$ ). To do this, we need to turn off the independent voltage source (in this case, the 10V battery) by short-circuiting it. Now, we need to find the equivalent resistance looking into the circuit from the perspective of N1 and N2. Since R1 is now in parallel with both R2 and R3, the equivalent resistance of the circuit is:

$$\frac{1}{R_{th}} = \frac{1}{R_1} + \frac{1}{R_{eq}} \quad \frac{1}{R_{th}} = \frac{1}{100} + \frac{1}{50} \quad \frac{1}{R_{th}} = \frac{1}{100} + \frac{2}{100} \quad \frac{1}{R_{th}} = \frac{3}{100} \quad R_{th} = 100/3 \text{ ohms}$$

The Thevenin equivalent of the circuit from the perspective of N1 and N2 is:

$$V_{th} = 50/15 \text{ V} \quad R_{th} = 100/3 \text{ ohms}$$

### Conclusion

The result is correct though it did not do the final math.

$$V_{th} = 50/15 = 3.33\text{V}$$

$$R_{th} = 100/3 = 33.3 \text{ ohms}$$

### Norton Equivalent

For the same circuit we asked for the Norton equivalent of the same circuit. The prompt was repeated in a fresh chat session with the following as the instructions.

### INPUT

...

*What is the Norton equivalent of this circuit from the perspective of N1 and N2?*

### ChatGPT-4 Output

To find the Norton equivalent of this circuit from the perspective of N1 and N2, we need to determine the Norton current ( $I_N$ ) and Norton resistance ( $R_N$ ). The Norton current is the current flowing through the short circuit between N1 and N2, and the Norton resistance is the equivalent resistance seen from the perspective of N1 and N2 when the voltage source is replaced with a short circuit.

First, let's analyze the circuit. From the given connections, we can see that R1 is in series with the parallel combination of R2 and R3.

Now, we will find the equivalent resistance ( $R_{eq}$ ) of the circuit and the total current ( $I_t$ ) flowing through the circuit.



1. Calculate the equivalent resistance of R2 and R3 ( $R2||R3$ ):

$$R2||R3 = (R2 * R3) / (R2 + R3) \quad R2||R3 = (100 * 100) / (100 + 100) \quad R2||R3 = 10000 / 200 \\ R2||R3 = 50 \text{ ohms}$$

2. Calculate the total equivalent resistance ( $R_{eq}$ ):

$$R_{eq} = R1 + (R2||R3) \quad R_{eq} = 100 + 50 \quad R_{eq} = 150 \text{ ohms}$$

3. Calculate the total current ( $I_t$ ) flowing through the circuit:

$$I_t = V / R_{eq} \quad I_t = 10V / 150 \text{ ohms} \quad I_t = 1/15 \text{ A (or approximately 0.067 A)}$$

Now, we'll find the Norton current ( $I_N$ ) and the Norton resistance ( $R_N$ ).

1. Determine the Norton current ( $I_N$ ):

Since N1 is connected to Pin 1 of R3, and N2 is connected to Pin 2 of R3, the Norton current is the same as the current flowing through R3.

We'll use the current division rule to find the current flowing through R3:

$$I_N = I_t * (R2 / (R2 + R3)) \quad I_N = (1/15 \text{ A}) * (100 / (100 + 100)) \quad I_N = (1/15 \text{ A}) * (1/2) \quad I_N = \\ 1/30 \text{ A (or approximately 0.0333 A)}$$

2. Determine the Norton resistance ( $R_N$ ):

To find the Norton resistance, we'll deactivate the voltage source by shorting it. This will put R1 in parallel with R2 and R3. We'll find the equivalent resistance of these parallel resistors.

$$R_N = R1 || (R2 || R3) \quad R_N = (R1 * (R2 || R3)) / (R1 + (R2 || R3)) \quad R_N = (100 * 50) / (100 + 50) \quad R_N = \\ 5000 / 150 \quad R_N = 100/3 \text{ ohms (or approximately 33.33 ohms)}$$

The Norton equivalent of the circuit from the perspective of N1 and N2 is a current source of 1/30 A (or approximately 0.0333 A) in parallel with a resistor of 100/3 ohms (or approximately 33.33 ohms).

## Conclusion

The Norton Current was not calculated correctly. The Norton Resistance was calculated correctly.



To cross check this the same procedure can be done with the Thevenin circuit results from above to get the Norton equivalent result.

Calculate the Norton Current ( $I_N$ ) by shorting  $N1$  and  $N2$ :

$$I_N = V_{th}/R_{th}$$

$$I_N = 3.33V/33.3 \text{ Ohms}$$

$$I_N = 0.1 \text{ Amps}$$

Calculate the Norton Resistance ( $R_N$ ) by shorting the power supply and measuring the resistance.

$$R_N = R_{th}$$

$$R_N = 33.3 \text{ Ohms}$$

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